

CRANIO-CEREBRAL TOPOGRAPHY.

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THE earliest of the serious attempts to demonstrate the relation of the brain convolutions to the cranium was that of Broca,¹ and his researches have been followed by those of Bischoff,² Turner,³ Féré,⁴ Pozzi,⁵ Giacomini,⁶ Ecker,⁷ Hefftler,⁸ Hare,⁹ R. W. Reid,¹⁰ Horsley,¹¹ and Cunningham.¹² The experiments of these observers may be classified into three principal groups. In the first, led by Broca, the cranial sutures were exposed, punctures were drilled at certain points in their course, and pegs or pins of wood or metal were introduced into the brain through the apertures; the more important relations of the convolutions to their bony case were thus laid down in a manner that involved no material source of fallacy beyond the variability of position of the sutures themselves in

¹ "Bulletins de la Société Anatomique," 1861.

² "Die Grosshirnwindungen des Menschen." München, 1868.

³ "Journal of Anatomy and Physiology," vol. viii. pp. 142-369.

⁴ "Bulletins de la Société Anatomique," 1875; and "Archives de Physiologie," 1876.

⁵ "Archives Générales de Médecine," 1877.

⁶ "Topografia della Scissura di Rolando." Torino, 1878.

⁷ "Archiv für Anthropologie," vol. x. 1876-78.

⁸ Ibid., p. 243.

⁹ "Journal of Anatomy and Physiology," Jan. 1884, p. 175.

¹⁰ "The Lancet," Sept. 27, 1884.

¹¹ "American Journal of the Medical Sciences," 1887.

¹² "The Lancet," May 26, 1888.

their relation to the cranium as a whole. In the second group various parts of the brain were exposed by removal of its investments, the organ having in some cases been prepared for the experiment either by injection of its vessels (Heffler) or by freezing (Féré). Thus Turner, having removed portions of the frontal, parietal, occipital, temporal, and sphenoid bones, left a number of regions (occipital or post-lambdoid, frontal or pre-coronal, antero-parietal or post-coronal, post-parietal or pre-lambdoid, and squamoso-sphenoidal) bounded either by sutures or by arbitrary lines and each containing certain convolutions or portions of convolutions. Heffler prepared a series of casts of different segments of the head (anterior, superior, and posterior), then of the corresponding portions of the bony cranium and of the brain. Lastly, Cunningham, having prepared the brain by a special process in such a manner that when exposed *in situ* it would remain absolutely unaltered for at least twenty-four hours, removed portions of the bone on one side, leaving narrow bars of the cranial wall in the lines of the suture, and temporal ridge. Moulds were taken, and from these were prepared the valuable series of models recently exhibited at the Royal Academy of Medicine in Ireland, and at the Anatomical Society of Great Britain. The third group, the most important for the surgeon, includes the various endeavours to localise the principal brain fissures by means of certain lines and admeasurements marked upon the shaven scalp. In these researches it was of course necessary that certain recognisable starting-points for the lines or measurements in question should be defined upon the surface of the cranium; and all parts of the skull that could be made available for the purpose—the glabella, the external occipital protuberance, the external angular process, the zygoma, the

mastoid process, the frontal and parietal eminences, the temporal ridges, the external auditory meatus, the borders of the orbit, and the coronal and lambdoid sutures—have been utilised in one or other of the three chief systems—that of the French school (Championnière and others), of Reid, and of Hare,—to which surgeons already owe a debt of gratitude.¹³

There is no doubt that by any of these carefully elaborated methods the brain points sought for could be exposed in the greater number of cases by a trephine of an inch in diameter, but there will be found in each plan certain disadvantages which render it occasionally untrustworthy. Thus, in the French system, the bregma is adopted as the fixed point by which the upper extremity of the fissure of Rolando (carried as far as the middle line) is to be discovered; but the coronal suture is variable in its relations to the rest of the cranial walls within limits which, though small ($\frac{3}{8}$ in.), are sufficient to introduce an undesirable source of error, and in a certain number of heads, perhaps one in every five or six, the ridge or depression commonly present at this spot is not perceptible through the scalp. The indications for the inferior extremity of the same sulcus, again, are inelastic, and, although probably accurate for crania of a certain type would be more or less incorrect in other cases. The same may be said for the points indicating the fissure of Sylvius. In the systems of Reid and Hare the indications for the localisation of the different parts of the fissure of Sylvius present material discrepancies, and in both the parietal eminence is adopted as a landmark for the termination of the sulcus (Reid, $\frac{3}{4}$ in. below, Hare, at the most prominent point), although the most central point of the boss is often hard to define

¹ Reid's diagram will be found in "The Lancet," vol. ii. 1884, p. 539; that of Hare in vol. i. 1888, p. 409.

and in any case its position is subject to a variation of an inch in the horizontal and nearly half an inch in the vertical direction.¹ The fissure of Rolando in Reid's method is found by two lines running perpendicularly upwards from a base line (which passes through the lower margin of the orbit and the external meatus) at points corresponding to the pre-auricular depression and the posterior border of the mastoid process; but, apart from the practical difficulty of erecting perpendicular lines upon a curved surface, it may be noticed that the posterior border of the mastoid process is seldom well defined, and that the breadth of the process varies to the extent of $\frac{3}{4}$ in., and under conditions which bear no reference to cerebral development. In Hare's system, the upper extremity of the fissure is found by a plan almost identical with that previously formulated in the last edition of Quain's Anatomy, and against which no objection can be raised, since it adjusts itself well to the varying size of the brain case. From this point the course of the sulcus is found by a line forming an angle of 67° with the sagittal line, and running downwards and forwards for a distance of $3\frac{3}{4}$ in.;² but it is not very easy to measure angles upon an irregularly curved surface, and the plan is, moreover, open to objection on the score of inelasticity. The external parieto-occipital fissure is placed by most observers beneath or near the apex of the lambdoid suture; but it may be shown that this, as an external landmark, has the same defects as the bregma. Reid, however, while recognising the relation of the sulcus to the suture, prefers to discover the position of the former by prolonging the Sylvian line to the sagittal line—a procedure

¹ See Table in "Journal of Anatomy and Physiology," 1889, p. 465.

² This angle was first estimated by Giacomini, who found it to range between 55° and 65° (115° – 125° with a vertical line).

which necessarily includes any defects that may belong to his method of tracing the fissure of Sylvius. A few other points for criticism might be raised, but the following tabulated list of indications given by different authorities for the position of the principal fissures will, perhaps, lay the matter before the reader in the shortest and most comprehensive manner.

I. FISSURE OF SYLVIVS.

(a) "*Commencement*":

Championnière : 3 cm. behind external angular process, and 5 cm. above zygomatic arch.

Hare : In the course of a line from external angular process to occipital protuberance, and $1\frac{1}{8}$ in. behind the process. Deviation in 17 heads, $\frac{1}{8}$ in.

Reid : $1\frac{1}{4}$ in. behind the external angular process.

(b) *Point of bifurcation* :

Thane and Godlee (Quain's Anatomy) : $1\frac{1}{4}$ in. behind and $\frac{1}{4}$ in. above external angular process.

Heftler : 1·3 cm. behind coronal suture and opposite spheno-squamosal suture.

Ecker : Corresponds to coronal suture, or not more than a few millimetres behind.

Reid : 2 in. behind and slightly above external angular process,

Merkel : 5 cm. to $5\frac{1}{2}$ cm. perpendicularly above middle of zygoma.

Hare : The ascending limb is described as corresponding to the squamoso-sphenoidal suture, but its point of commencement is not localised.

Horsley : 1 to 2 millimetres anterior to spheno-squamous suture, midway between stephanion and zygoma.

(c) Course of posterior limb :

Broca : Opposite level of squamo-parietal suture, and hence about 5 cm. above zygomatic arch.

Reid : A line commencing 2 in. behind and a little above external angular process, and extending to a point $\frac{3}{4}$ in. below centre of parietal eminence.

Seguin : Along line from external angular process to tip of lambda (corresponding closely to Reid's line).

Hare : A line from commencement of fissure (see above) to centre of parietal eminence.

Horsley : Commencing midway between stephanion and zygoma, extends along squamo-parietal suture nearly up to parietal eminence. The squamo-parietal suture lies at junction of middle and superior thirds of line from temporal ridge to zygoma, just anterior to temporo-maxillary articulation.

2. FISSURE OF ROLANDO.

(a) Upper extremity :

Broca, Championnière, Féré, and others : $4\frac{1}{2}$ cm. to 5 cm. behind bregma. Distance never exceeds 5.7 cm., but there is great variation in pathological conditions.

Thane and Godlee : $\frac{1}{2}$ in. behind middle of a line drawn from the root of the nose to the external occipital protuberance.

Hare : 55.7 per cent. of distance between glabella and external occipital protuberance.

Reid : Touched by the upper end of a line drawn from the posterior border of the mastoid process perpendicularly to a base line extending from the lower

border of the orbit through the middle of the external auditory meatus.

Merkel: Touched by the upper end of a line drawn in a direction perpendicular to the zygoma from the posterior border of the mastoid process.

Seguin: A line corresponding closely to that of Reid and Merkel, but drawn perpendicular to a base line extending from the cusps of the upper teeth to the tip of the mastoid process. (A modification of Féré's alveolo-condylar plane.)

(b) *Lower extremity:*

Féré: $2\frac{1}{2}$ cm. to 3 cm. behind lower extremity of coronal suture, which lies 15 mm. to 20 mm. behind external angular process at the level of the superciliary ridge.

Championnière: A point 7 cm. behind and 3 cm. above external angular process.

Thane and Godlee: About 1 in. behind bifurcation of fissure of Sylvius (see above).

Hare: See below (c).

Reid: Touched by a line carried at right angles to the baseline(see above) from the pre-auricular depression.

Seguin: Touched by a line drawn perpendicular to the alveolo-condylar plane through the middle of the external auditory meatus. This line reaches the bregma above (auriculo-bregmatic line).

Merkel: Touched by a line drawn perpendicular to the zygoma through the temporo-maxillary articulation.

(c) *Direction of fissure of Rolando.*

Giacomini: A line drawn at right angles to the sagittal line from the greatest transverse diameter of the head (measured with calipers) cuts the fissure

of Rolando nearly in the middle, and the decussation lies exactly midway between the sagittal line and the point of the greatest transverse diameter. The fissure forms an angle of 115° to 125° with the vertical line (or 55° to 65° with the sagittal line). Crania examined were all of strongly brachycephalic type.

Hare: Course of fissure indicated by a line passing from its upper extremity (see above) downwards and forwards for $3\frac{3}{4}$ inches at an angle of from 60° to 73° (average 67°) with the sagittal line.

3. EXTERNAL PARIETO-OCCIPITAL FISSURE.

Féré: Summit of lambdoid suture: exactly in 35 cases, 1 to 4 mm. anterior in 17 cases, and 2 to 3 mm. behind in 2 cases. (Subjects examined all women, mostly over sixty, and forming part of the clinique of M. Charcot.)

Heftler: usually opposite to summit of lambdoid suture.

Hare: $1\frac{1}{2}$ in. to $2\frac{1}{4}$ in (average $1\frac{7}{8}$ in.) from upper extremity of fissure of Rolando, $\frac{5}{8}$ in. anterior to lambda.

Thane and Godlee: Summit of lambdoid suture, 2 in. to 3 in. from external occipital protuberance.

Reid: Posterior extremity of line continued from fissure of Sylvius to sagittal line.

Merkel: Beneath or a few millimetres behind summit of lambdoid suture (about 6 cm. above external occipital protuberance).

Horsley: 2 mm. to 3 mm. anterior to apex of lambdoid suture.

The details of the investigations which have led us to propose

a new system, will be found in the "Journal of Anatomy and Physiology."¹ It will be sufficient here to state that the principal researches were carried out by means of experimental punctures made at certain points previously marked upon the scalp, and that the subjects were twenty in number—fourteen men, three women, and three children (aged two and a half, eight, and fourteen),—but, as both hemispheres were examined in each case, the total observations for each fissure may be taken as forty. Broca's method was adopted in preference to any other, because in that the relations between brain and cranial wall are in no way disturbed, and if the point of perforation be carefully fixed there is no reasonable probability of errors of observation. A supplementary set of examinations dealt with the relation of certain of the cranial sutures, eminences, &c., to the skull as a whole, with a view to determine the range of variation of the landmarks hitherto employed in cerebral localisation. The main general deductions from the experiments were: first, that the normal variability of the fissures is very considerable in different subjects, and even on the two sides of the same brain, and it is only by finding the mean of the variations that the best position for the application of the trephine can be calculated; and secondly, that the positions of the various sutures, eminences, and ridges are not entirely or equally trustworthy as indications of the localities of the cerebral convolutions, as the former may vary under conditions that have no influence upon the latter. This being stated, it is only necessary to refer to the diagrams showing the plan of construction of our cranial chart, and the relations to it of the more important cerebral sulci. (See Figs. 1, 2.)

¹ Vol. xxiii. (1889), p. 455.

It will be noticed that the standard points are few, and are liable only to a very small degree of variation in different subjects; that the frontal and squamosal lines by which the course of the fissures of Rolando and Sylvius are mainly in-

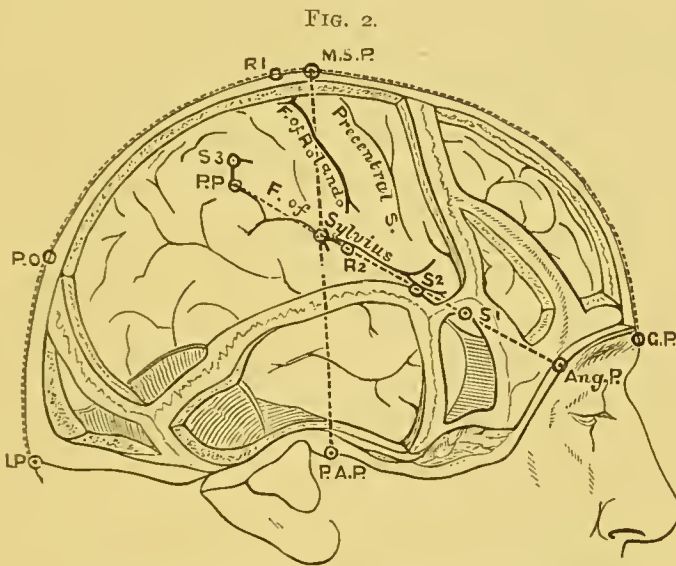
FIG. 1.



Cranio-cerebral guiding lines, traced upon a cast of Professor Cunningham's (from a photograph). GP, Glabellar point; glabella opposite superior border of orbit. IP, Initial point, at external occipital protuberance. MS.P, Mid-sagittal point; midway between GP and IP. Ang.P, Angular point; external angular process opposite upper border of orbit. Sq.P, Squamosal point; intersection of squamosal and frontal lines at junction of middle and lower thirds of latter. PP, Parietal point; termination of squamosal line, equidistant with FS² from squamosal point. Aur.P, Pre-auricular point; depression in front of tragus, at level of upper border of external auditory meatus. FS¹, "Commencement" of fissure of Sylvius, $\frac{1}{3}$ ths of distance from Ang.P. to Sq.P. FS², Bifurcation of fissure of Sylvius, $\frac{1}{3}$ ths of distance from Ang.P. to Sq.P. FS³, Termination of fissure of Sylvius, $\frac{1}{2}$ an inch above PP, in a direction parallel to frontal line. FR¹, Upper extremity of fissure of Rolando carried to sagittal line in direction of fissure, $\frac{1}{2}$ th of an inch behind mid-sagittal point. FR², Lower extremity of fissure of Rolando carried to squamosal line in direction of fissure, $\frac{1}{3}$ th of an inch in front of squamosal point. PO, External parieto-occipital fissure, carried to sagittal line in direction of fissure, $\frac{1}{3}$ th of distance from MS.P. to IP.

licated undergo changes of length and direction in association with variations in the size and form of the skull, and are hence applicable for heads of all dimensions and types, and appear to be adaptable for children as well as adults; and

that the test points in the course of the different fissures are measured as far as possible in fractions of the length of the lines, and not in inches and centimetres, in order to secure a similar adaptation to crania of all dimensions. This rule is departed from only in the case of the two extremities of the fissure of Rolando, where the necessary adaptive changes are sufficiently secured by the shifting of the frontal line.



Outline traced from a photograph of a cast of Professor Cunningham's. For references see Fig. 1.

The following indications may now be quoted from our paper in the "Journal of Anatomy and Physiology."

1. *Fissure of Rolando*.—The upper extremity, carried for convenience of admeasurement as far as the longitudinal fissure (in line of the sulcus), was found to lie in all cases between the mid-sagittal point and a point three-quarters of an inch behind it. Its distance behind the mid-sagittal point, however, bore no constant relation to the length of the sagittal line, and hence the central spot for the application of the trephine may be most safely fixed, for adults, at three-eighths

of an inch behind the mid-sagittal point. The superior connecting gyrus between the pre-central and post-central (ascending frontal and parietal) convolutions occasionally appears only on the mesial surface of the hemisphere—in this case the fissure of Rolando actually reaches the longitudinal fissure. The lower end of the sulcus, carried into the fissure of Sylvius, lies in the squamosal line between the junction of this line with the frontal line (squamosal point), and three-fourths of an inch in front of this. The centre of the trephine may hence be applied, in the squamosal line, three-eighths of an inch in front of the squamosal point. In four instances the sulcus really joined the horizontal limb of the Sylvian fissure. The angle formed, with the upper border of the hemisphere, by a line connecting the two extremities of the fissure of Rolando, in eight cases was found to range between 55° and 70° , in twelve out of the sixteen fissures falling between 60° and 65° . The course of the fissure is extremely capricious, and tracings taken from opposite hemispheres often differ considerably from each other. (See illustration in "Journal of Anatomy and Physiology.") A strong curve with a backward convexity is not unfrequently met with in the upper third, and a second smaller curve in the opposite direction may sometimes be found near the lower extremity of the sulcus.

2. *Fissure of Sylvius*.—The place at which the frontal and temporo-sphenoidal lobes appear to separate when seen from the lateral aspect of the brain—the so-called "commencement of the fissure of Sylvius"—can scarcely, from its very nature, be fixed with complete exactness, but it may be computed with sufficient accuracy for all practical purposes. It was found to lie in the squamosal line between $1\frac{1}{8}$ in. and $1\frac{1}{2}$ in. behind the external angular processes, or about $\frac{5}{12}$ th

of the distance between the point and the frontal line. The bifurcation of the fissure lies in the squamosal line at a point from $1\frac{1}{2}$ in. to 2 in. behind the external angular process, or at $\frac{7}{12}$ ths of the distance between this process and the frontal line.¹ The course of the horizontal limb from the bifurcation to the frontal line corresponds closely to the squamosal line and a continuation of this backwards for an equal distance behind the frontal line (to parietal point in diagram), it then turns upwards for about half an inch in a direction parallel to the frontal line. The mode of termination of the fissure is, however, so uncertain, that a circle of an inch in diameter failed to cover all the variations in the twenty subjects examined by us. The parietal eminence is nearly always closely related to the point in question.

3. The *external parieto-occipital fissure* joins the longitudinal fissure at a point averaging $\frac{7}{12}$ ths of the distance measured from the mid-sagittal point to the external occipital protuberance, and lies near to the apex of the lambdoid suture. In operations in the neighbourhood of the longitudinal fissure, it is of course necessary to take into consideration the width of the superior longitudinal sinus and its frequent deviation towards the right side in the posterior half of its course. An endeavour was made to ascertain the average positions of the superior and inferior frontal fissures, but these were found to be so irregular in their course as to baffle all attempts to secure indications of any value.

As a practical point it should be mentioned that the mobility of the integumental structures covering the cranium may lead to a misplacement of the trephine aperture, and to

¹ The division of the squamosal and sagittal lines into twelfths is readily calculated by employing a measure graduated in lines.

obviate this source of error it is desirable to pierce with a strong needle or pin the soft parts at the centre of the spot marked for investigation, and fix the point of the instrument in the bone before making the incision for the exposure of the required portion of the skull cap. The small depression in the outer table will then serve for the application of the pin of the trephine.